HEIDENHAIN

## User's Manual

# ND 720
# ND 760

## Position Display Units for Milling Machines

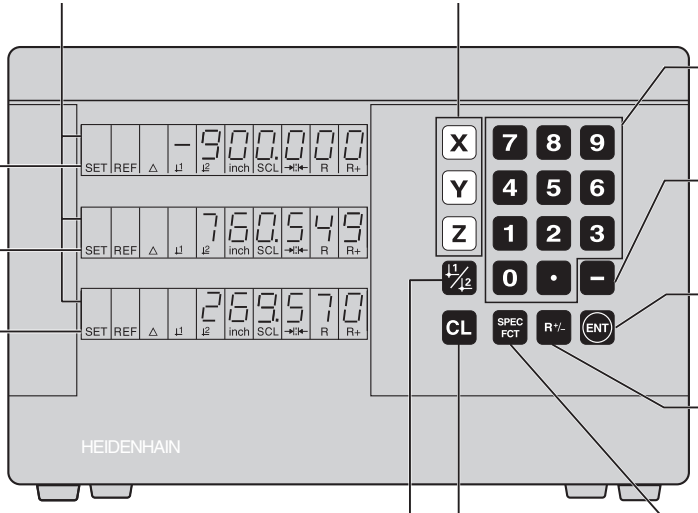
6/99

**Position display**
**(ND 720 only two axes)**

- **Select coordinate axes (ND 720 only X and Y)**
- **Select axis-specific operating parameters**

**Status display:**

SET = Datum setting
REF = blinking:
Traverse the reference points.
On continuously:
Reference points have been traversed.
Δ = Distance-to-go display
1 2 Datum 1 or 2
Inch = Display in inches
SCL = Scaling factor
->||<- = Probing an edge / centerline
R = Radius/diameter display
R+/– = Radius compensation




**Numerical input**

- **Change the algebraic sign**
- **Call the last dialog**
- **In the parameter list: change parameters**
- **Confirm entry**
- **In the parameter list page forward**

**Call radius compensation of the current tool**

- **Select special functions**
- **In the list of special functions page forward**

- **Select datum 1 or 2**
- **Page backward in the list of special functions**
- **Page backward in the list of parameters**

- **Cancel entry**
- **Reset the operating mode**
- **Zero the selected axis (if activated in P80)**
- **Select parameters CL plus two-digit number**

This manual is for the ND display units with the following software numbers or higher:

| | |
|---|---|
| **ND 720 for two axes** | **AA00** |
| **ND 760 for three axes** | **AA00** |

### About this manual

This manual is divided into two parts:

**Part I: Operating Instructions**

- Fundamentals of positioning
- ND functions

**Part II: Installation and specifications**

- Mounting the display unit on the machine
- Description of operating parameters
- Switching inputs, switching outputs

# Part I Operating Instructions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**Part II Installation and Specifications** **Page 29**

## Fundamentals

You can skip this chapter if you are already familiar with coordinate systems, incremental and absolute dimensions, nominal positions, actual positions and distance-to-go.

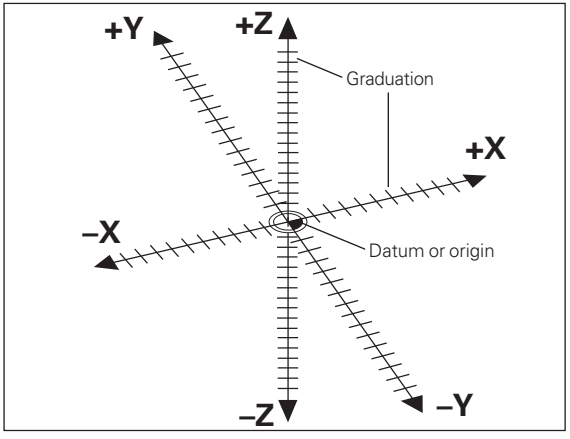
### Coordinate system

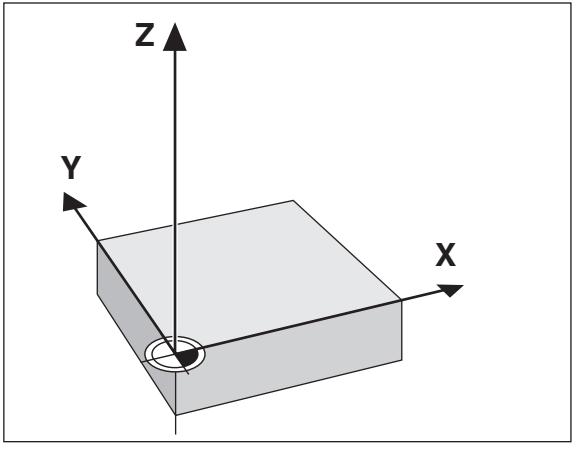
The *Cartesian*[1] coordinate system is used to describe the geometry of a workpiece. The Cartesian coordinate system consists of three mutually perpendicular axes X, Y and Z. The point of intersection of these axes is called the **datum** or origin of the coordinate system.

Think of the axes as scales with divisions (usually in millimeters) which allow us to fix points in space referenced to the datum.

To determine positions on a workpiece, the coordinate system is "laid" onto the workpiece.

The machine axes are parallel to the axes of the coordinate system. The Z axis is normally the tool axis.




[1] Named in honor of the French mathematician and philosopher René Descartes (1596 to 1650)

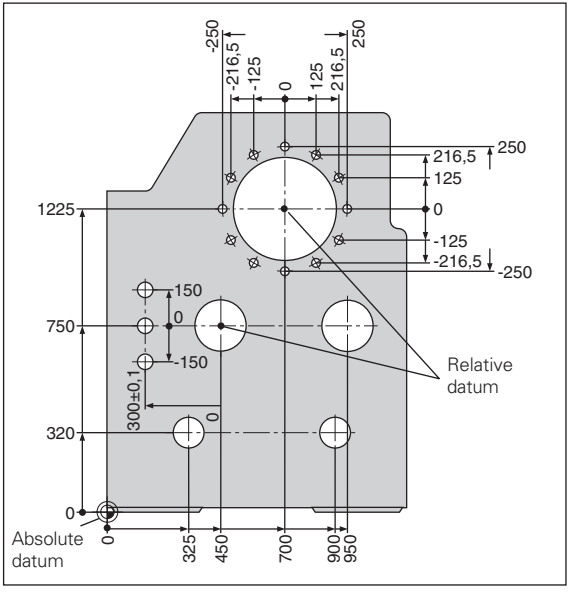
## Datum setting

The workpiece drawing is used as the basis for machining the workpiece. To enable the dimensions in the drawing to be converted into traverse distances of machine axes X, Y and Z, each drawing dimension requires a datum or reference point on the workpiece (since a position can only be defined in relationship to another position).

The workpiece drawing always indicates **one** absolute datum (the datum for absolute dimensions). However, it may contain additional relative datums.

In the context of a numerical position display unit, *datum setting* means bringing the workpiece and the tool into a defined position in relation to each other and then setting the axis displays to the value that corresponds to that position. This establishes a fixed relationship between the actual positions of the axes and the displayed positions.

You can set 2 absolute datum points and store them in nonvolatile memory.



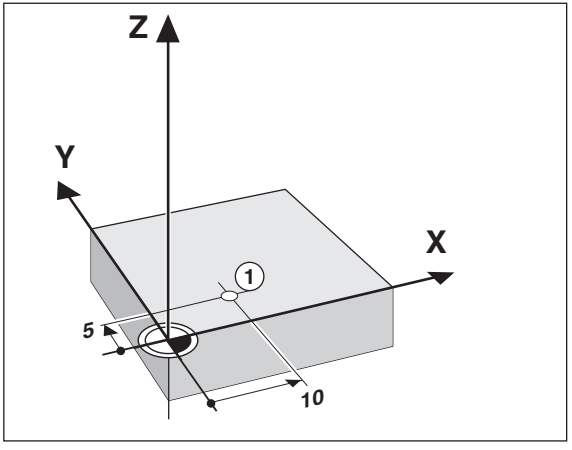
### Absolute workpiece positions

Each position on the workpiece is uniquely defined by its absolute coordinates.

**Example** Absolute coordinates of position ①:

X = 10 mm
Y = 5 mm
Z = 0 mm

If you are working according to a workpiece drawing with absolute dimensions, then you are moving the tool **to** the coordinates.



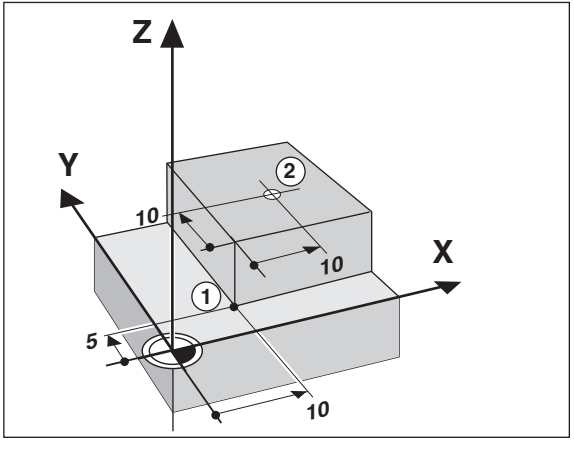

### Relative workpiece positions

A position can also be defined relative to the previous nominal position. The datum for the dimension is then located at the previous nominal position. Such coordinates are termed **relative coordinates** or chain dimensions. Incremental coordinates are indicated by a preceding **I**.

**Example** Relative coordinate of position ② referenced to position ①:

IX = 10 mm
IY = 10 mm

If you are working according to a workpiece drawing with incremental dimensions, then you are moving the tool **by** the dimensions.



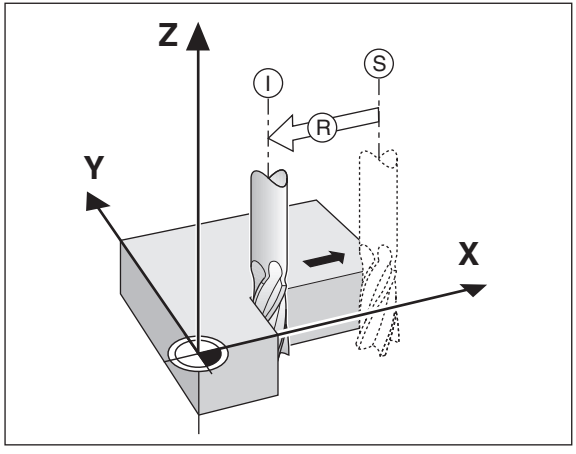

### Sign for incremental dimensioning

A relative dimension has a **positive** sign when the axis is moved in the positive direction, and a **negative** sign when it is moved in the negative direction.

### Nominal position, actual position and distance-to-go

The position to which the tool is to move is called the **nominal** position (Ⓢ). The position at which the tool is actually located at any given moment is called the **actual** position (Ⓘ).

The distance from the nominal position to the actual position is called the distance-to-go (Ⓡ).



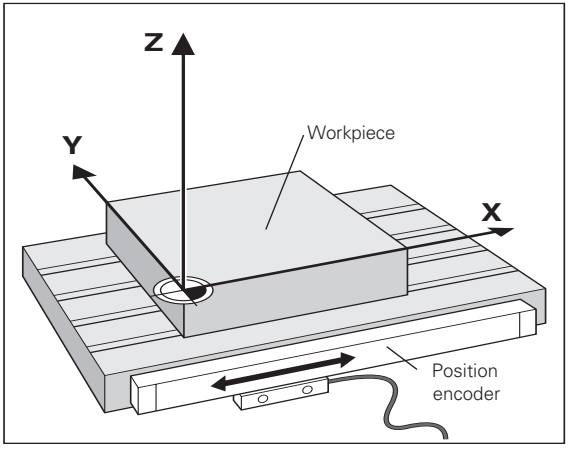

### Sign for distance-to-go

When you are using the distance-to-go display, the nominal position becomes the relative datum (display value 0). The distance-to-go is therefore negative when the tool moves in the positive axis direction, and positive when it moves in the negative axis direction.

## Position encoders

The position encoders on the machine convert the movements of the machine axes into electrical signals. The ND display unit evaluates these signals, determines the actual position of the machine axes and displays the position as a numerical value.

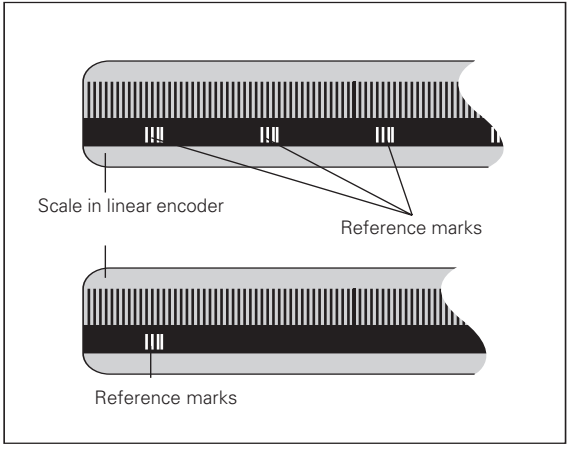
If the power is interrupted, the relationship between the machine axis positions and the calculated actual positions is lost. The reference marks on the position encoders and the REF reference mark evaluation feature enable the ND to quickly reestablish this relationship again when the power is restored.




## Reference marks

The scales of the position encoders contain one or more reference marks. When a reference mark is crossed over, a signal is generated which identifies that position as a reference point (scale datum = machine datum).

When this reference mark is crossed over, the ND's reference mark evaluation feature (REF) restores the relationship between axis slide positions and display values which you last defined by setting the datum. If the linear encoders have **distance-coded** reference marks, you only need to move the machine axes a maximum of 20 mm to do this.



## Switch-On, Traversing the Reference Marks

| | |
|---|---|
| 0 → 1 | Turn on power (switch located on rear panel). "REF" and decimal points in status display blink. |

| ENT...CL | |
|---|---|
| ENT | Confirm reference traverse mode. "REF" remains on continuously. Decimal points blink. |
| | Cross over the reference marks in all axes in any sequence. Each axis display becomes active when its reference mark is crossed over. |

Crossing over the reference marks stores the most recently defined assignment of display values to axis slide positions for datum points 1 and 2 in nonvolatile memory.

Note that if you choose *not* to traverse the reference marks (by clearing the dialog ENT ... CL with the CL key), this relationship will be lost if the power is interrupted or when the unit is switched off.

If you wish to use multipoint axis error compensation you must traverse the reference marks (see "Multipoint axis error compensation")!

## Datum Setting

If you want to save the datum points in nonvolatile memory, you must first cross over the reference marks.

Only after crossing over the reference marks can you set new datums or activate existing ones.

There are two ways to set datums:

**Touch the workpiece with the tool** and then set the desired datum (see example). You can also touch two edges and set the centerline between them as a datum. The dimensions of the tool used for this are automatically accounted for (see "Tool Compensation").

**Probe the workpiece with the edge finder** and then set the desired datum, or probe two edges and set the centerline as datum (see example). The stylus radius and length are automatically accounted for if they have been entered in parameters P25 and P26, respectively (see "operating parameters").

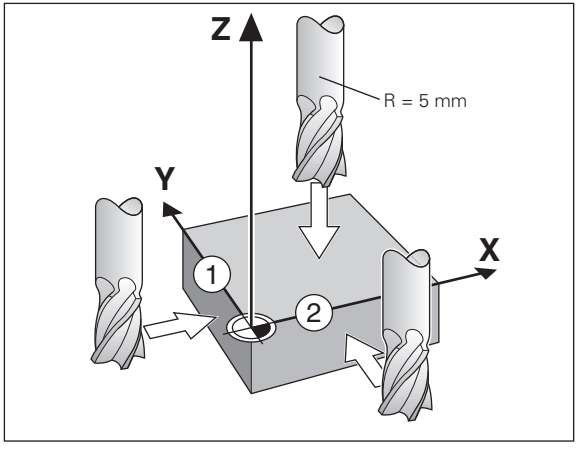
After you have set a datum, it can be activated as follows:

| | |
|---|---|
| ↓1 / ↓2 | Select datum 1 or 2. |

**Datum setting with the tool**

**Example:**

| | |
|---|---|
| Working plane | X / Y |
| Tool axis | Z |
| Tool radius | R = 5 mm |
| Axis sequence for datum setting | X – Y – Z |



| | |
|---|---|
| ↓1 ↓2 | Select the datum number. |
| SPEC FCT | Select special functions. |
| SPEC FCT or ↓1 ↓2 | Select "probing function." |
| **PROBING** | |
| ENT | Confirm selection. |
| **PROBE EDGE** | |
| ENT | Confirm "Probe edge." |
| X | Select X axis (if not already selected). SET lights up. The I<- symbol blinks. |
| **PROBE X** (appears only briefly) | |
| | Touch workpiece edge ① with the tool. |
| • • • | |

| | |
|---|---|
| ENT | X position is captured. "SET" blinks. Retract tool from workpiece. The I<- status symbol lights. |
| 0 ENT | Enter position value for the datum. Tool radius is automatically compensated. |
| Y | Select the Y axis. "SET" lights up. The I<- status symbol blinks. |
| **PROBE Y** (appears only briefly) | |
| | Touch workpiece edge ② with the tool. |
| ENT | Y position is captured. "SET" blinks. Retract tool from workpiece. The I<- status symbol lights. |
| 0 ENT | Enter position value for the datum in the Y axis. Tool radius is automatically compensated. |
| • • • | |

| | |
|---|---|
| Z | Select the Z axis. “SET” lights.<br>The I<- status symbol blinks. |
| **PROBE Z** (appears only briefly) | |
| | Touch the top of the workpiece with the tool. |
| ENT | Z position is captured. “SET” blinks.<br>Retract the tool from the workpiece.<br>The I<- status symbol lights. |
| 0 ENT | Enter the position value for the datum in the Z axis. |
| SPEC FCT or CL | After setting the datum, exit the probing functions. |

## Datum Setting with the KT Edge Finder

The ND position display units provide the following probing functions:

Edge Probing: Setting a workpiece edge as datum

Center Probing: Setting a midpoint between two workpiece edges as datum

The probing functions are accessible in the SPEC FCT mode of operation.

Before using the edge finder you must enter the stylus diameter and length in parameters P25 and P26, respectively (see "Operating Parameters").

During all probing functions, the ND position display unit accounts for the entered dimensions.

The Edge Probing and Center Probing functions are describe on the following pages.

**Probing a workpiece edge to find a datum**

The edge to be probed is parallel to the Y axis. You can probe edges and surfaces as described below to set all the coordinates of a datum.

| | |
|---|---|
| | Select a datum number. |
| | Select special functions. |
| | Select "probing functions." |
| **PROBING** | |
| | Confirm "probing" function. |
| **PROBE EDGE** | |
| | Confirm "probe edge" function. |

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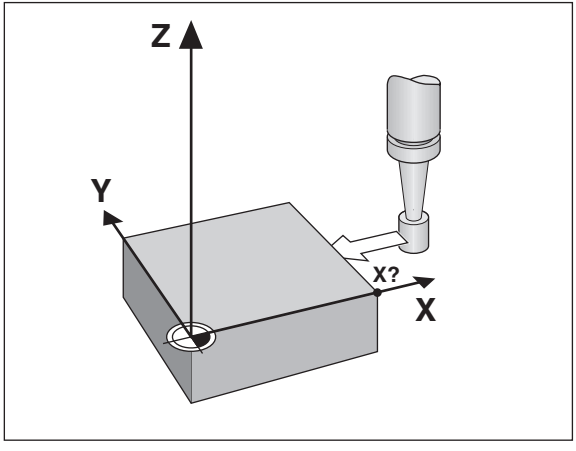

| | |
|---|---|
| X | If required, select the X axis. “SET” lights. The I< status symbol starts blinking. |

**PROBE X** (appears only briefly)

| | |
|---|---|
| | Move the edge finder to edge of workpiece until indicator in edge finder lights. “SET” begins to blink. The ND displays the position of the edge. The I< status symbol lights. |
| | Back the edge finder away from the workpiece. |
| 5 2 ENT | Assign a position value to this edge, e.g. 52. |
| SPEC FCT or CL | Exit the probing function. |

**Probing workpiece edges to find a midpoint datum**

The edges probed must be parallel to the Y axis.

Follow the procedure below for all midpoints between two edges.

| | |
|---|---|
| [1/2] | Select a datum number. |
| SPEC FCT | Select the special functions. |
| SPEC FCT or [1/2] | Select the probing function. |
| **PROBING** | |
| ENT | Confirm the probing function. |
| **PROBE EDGE** | |
| [1/2] or [−] | Select the midpoint probing function. |

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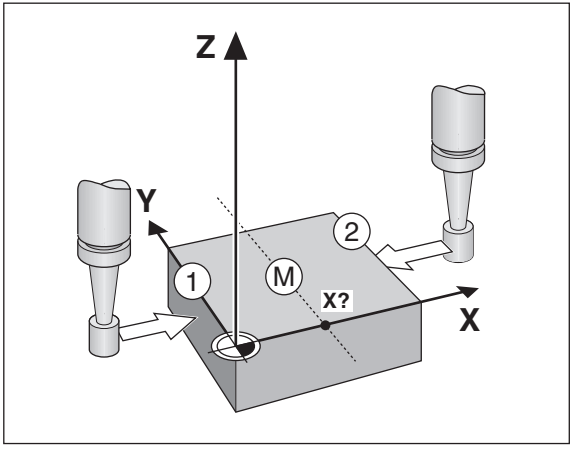


**PROBE MIDP.**

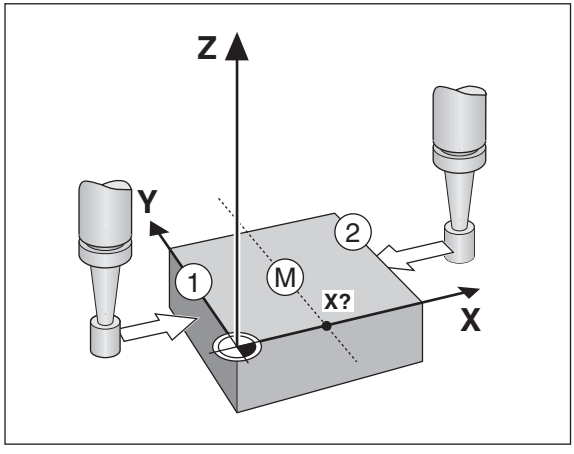
| | |
|---|---|
| ENT | Confirm the "probe midpoint" function. "SET" lights. |
| X ENT | If required, select the X axis and confirm with ENT. The ->‖<- status symbol starts blinking. |

**1ST POS X** (appears only briefly)

| | |
|---|---|
| | Move edge finder toward workpiece edge ① until the indicator in the edge finder lights. Back edge finder away from the workpiece. |

**2. POS X** (appears only briefly)

| | |
|---|---|
| | Move edge finder toward workpiece edge ② until the indicator in the edge finder lights. "SET" begins to blink. Back the edge finder away from the workpiece. The ->‖<- symbol begins to blink. |
| 2 6 ENT | Set the position value for the midpoint between the edges, e.g. 26. |
| SPEC FCT or CL | Exit the probing functions. |



## Tool Compensation

You can enter the axis, length and diameter of the current tool.

| | |
|---|---|
| SPEC FCT | Select the special functions. |

| | |
|---|---|
| SPEC FCT or ↓1/↓2 | Select "tool diameter." |

| TOOL DATA | |
|---|---|
| ENT | Confirm tool data input mode. |

| TOOL DIAM. | |
|---|---|
| 2 0 ENT | Enter the tool diameter, e.g. 20 mm, and confirm with ENT. |

| TOOL LENGTH | |
|---|---|
| 5 0 ENT | Enter the tool length, e.g. 50 mm, and confirm with ENT. |

1)

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| TOOL AXIS | |
|---|---|
| Z | Set the tool axis. |

| TOOL AXIS | |
|---|---|
| SPEC FCT or CL | Exit the special functions. |

1) only by ND 760

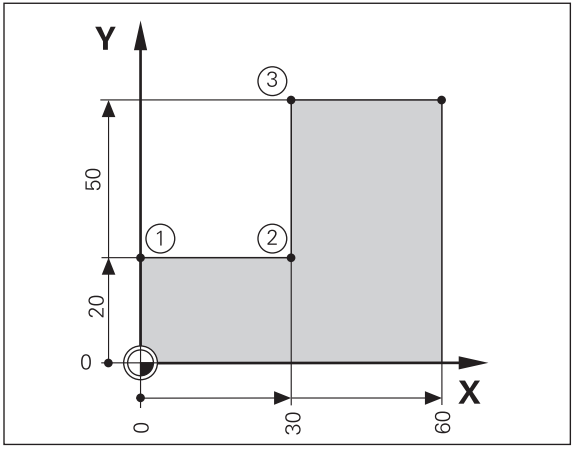
## Moving the Axes with Distance-To-Go Display

Normally, the display shows the actual position of the tool. However, it is often more helpful to display the distance remaining to the nominal position (the distance-to-go). You can then position simply by moving the axis until the display value is zero.

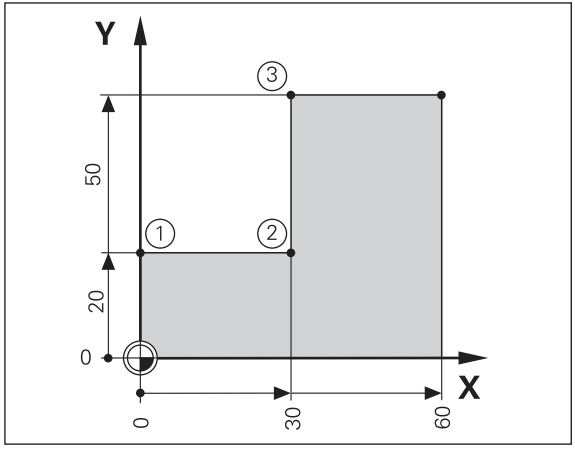
You can enter the absolute coordinates in the distance-to-go display. An active radius compensation will be considered.

**Example: Milling a shoulder with distance-to-go**

| | |
|---|---|
| SPEC FCT | Select the special functions. |
| SPEC FCT or ↓1/↓2 | Select "delta mode." |
| **DELTA MODE** | |
| ENT | Confirm your selection, the Δ symbol lights. |
| Y 2 0 R+/- <br> ENT | Select the axis, enter the nominal value, e.g. 20 mm, select radius compensation R+, confirm with ENT. |



| | |
|---|---|
| | Move the machine axis to zero (①). |
| X 3 0 R+/- R+/- ENT | Select the axis, enter the nominal value, e.g. 30 mm, select radius compensation R–, and confirm with ENT. |
| | Move the machine axis to zero (②). |
| Y 5 0 R+/- ENT | Select the axis, enter the nominal value, e.g. 50 mm, select radius compensation R+, confirm with ENT. |
| | Move the machine axis to zero (③). |
| SPEC FCT ENT or CL | If appropriate, switch off the distance-to-go display. |



## Bolt Hole Circles and Bolt Circle Segments

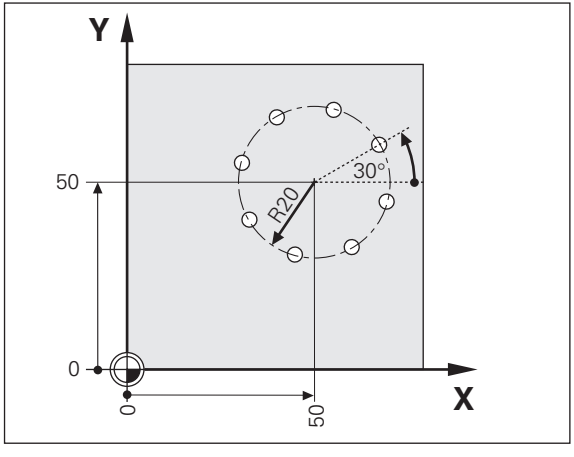
Your display unit enables you to quickly and easily produce bolt hole circles and bolt hole circle segments. The required data is requested in the message field.

Each hole can be moved to by traversing to display value zero. This requires entry of the following data:

- Number of holes (maximum: 999)
- Circle center
- Circle radius
- Starting angle for first hole
- Angle step between the holes (only for circle segments)
- Hole depth

**Example**

| | |
|---|---|
| Number of holes | 8 |
| Coordinates of the center | X = 50 mm |
| | Y = 50 mm |
| Circle radius | 20 mm |
| Starting angle | 30 degrees |
| Hole depth | Z = –5 mm |



| | |
|---|---|
| SPEC FCT | Select the special functions. |

| | |
|---|---|
| SPEC FCT, ↓1/↓2 | Select "bolt hole" circle. |

**BOLT HOLE**

| | |
|---|---|
| ENT | Confirm your selection. |

**FULL CIRCLE**

| | |
|---|---|
| if req. –, ENT | Confirm "full circle." |

**NUMB. HOLES**

| | |
|---|---|
| 8, ENT | Enter the number of holes, e.g. 8. Confirm with ENT. |

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**CENTER X**

| | |
|---|---|
| X, 5, 0, ENT | Enter the X coordinate of circle center, e.g. 50 mm, confirm with ENT. |

**CENTER Y**

| | |
|---|---|
| Y, 5, 0, ENT | Enter the Y coordinate of circle center, e.g. 50 mm, confirm with ENT. |

**RADIUS**

| | |
|---|---|
| 2, 0, ENT | Enter the radius of the bolt hole circle, e.g. 20 mm. Confirm with ENT. |

**START ANGLE**

| | |
|---|---|
| 3, 0, ENT | Enter the start angle for the first hole, e.g. 30°. Confirm with ENT. |

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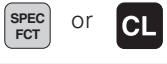
**HOLE DEPTH**

Enter the total hole depth, e.g. –5 mm, and confirm with ENT.

**START**

Start the display of the hole positions.

After the start, the distance-to-go mode becomes active (the Δ symbol lights). The hole number is shown briefly in the X axis. The individual holes are reached by traversing to zero. The holes can be selected with the ENT key or the ↓1 ↓2 key. The minus key shows the hole number again.




Exit the bolt hole circle function.

## Linear Hole Patterns

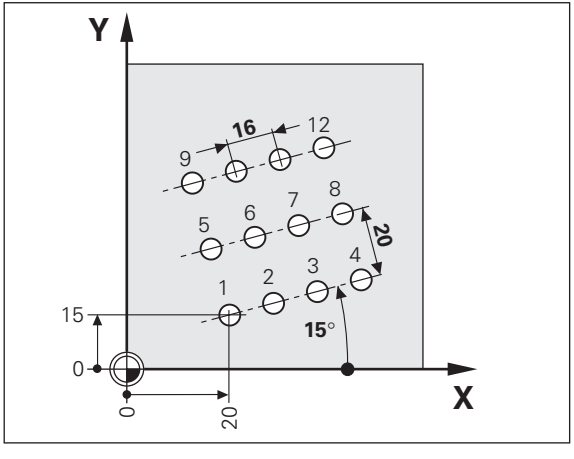
The linear hole pattern feature allows you to easily create rows of holes to cover an area. The required data are requested in the message field.

You can position to each hole by traversing to display value zero. The following data are required:

- Coordinates of the first hole
- Number of holes per row (maximum: 999)
- Spacing between holes
- Angle between the rows and the reference axis
- Hole depth
- Number of rows (maximum: 999)
- Spacing between rows

### Example

| | |
|---|---|
| Coordinates of the first hole | X = 20 mm |
| | Y = 15 mm |
| Number of holes per row | 4 |
| Spacing between holes | 16 mm |
| Angle | 15 degrees |
| Hole depth | Z = -30 mm |
| Number of rows | 3 |
| Spacing between rows | 20 mm |



| | |
|---|---|
| SPEC FCT | Select special functions. |
| SPEC FCT ↓1/↓2 | Select "hole pattern." |

**LIN. HOLE**

| | |
|---|---|
| ENT | Confirm "linear hole" pattern. |

**1ST HOLE X**

| | |
|---|---|
| 2 0 ENT | Enter the X coordinate of the first holes, e.g. 20, and confirm with ENT. |

**1ST HOLE Y**

| | |
|---|---|
| 1 5 ENT | Enter the Y coordinate of the first holes, e.g. 15, and confirm with ENT. |

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**HOLES ROW**

| | |
|---|---|
| 4 ENT | Enter the number of holes per row, e.g. 4, and confirm with ENT. |

**HOLE SPACE**

| | |
|---|---|
| 1 6 ENT | Enter the spacing between holes in the row and confirm with ENT. |

**ANGLE**

| | |
|---|---|
| 1 5 ENT | Enter the angle, e.g. 15 degrees, and confirm with ENT. |

**HOLE DEPTH**

| | |
|---|---|
| 3 0 – ENT | Enter the hole depth, e.g. –30 mm, and confirm with ENT. |

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| NUMBER ROW | |
|---|---|
| 3 ENT | Enter the number of rows, e.g. 3, and confirm with ENT. |

| ROW SPACE | |
|---|---|
| 2 0 ENT | Enter the spacing of the rows, e.g. 20, and confirm with ENT. |

| START | |
|---|---|
| ENT | Start the display of hole positions. |

| | |
|---|---|
| ENT ↓1/↓2 | The distance-to-go mode is now active (the Δ symbol lights). The hole number appears briefly in the X axis. Move to the individual hole positions by traversing to the display value zero. Hole can be selected with the ENT key or with the ↓1 ↓2 key. Pressing the minus key shows the hole number again. |

| | |
|---|---|
| SPEC FCT or CL | Exit the linear hole patterns function. |

## Working with Scaling Factors

Scaling factors enable you to increase or decrease the display values based on the actual traverse distance. The display values are changed symmetrically about the datum.

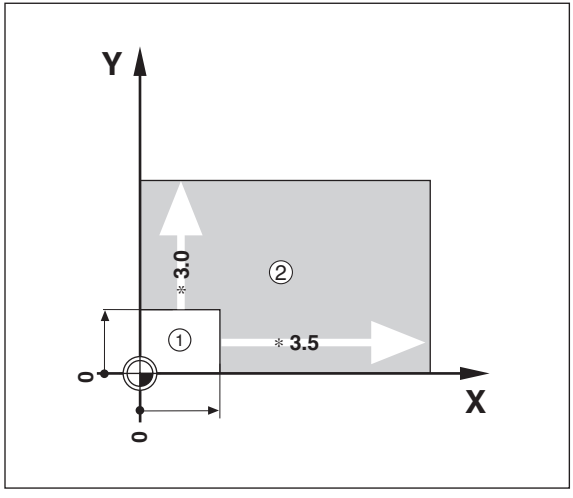
Enter scaling factors separately for each axis in parameter P12.

Parameter P11 activates and deactivates the scaling factors in all axes (see "Operating Parameters").

Example for enlarging a workpiece:

| | |
|---|---|
| P12.1 | 3.5 |
| P12.2 | 3.0 |
| P11 | ON |

This results in a larger workpiece as shown in the illustration at right: ① is the original size, ② is with axis-specific scaling factors.




If a scaling factor is active, "SCL" lights in the status display.

## Error Messages

| Message | Cause and Effect |
|---|---|
| **RS TOO FAST** | Time interval between two commands too short. |
| **SIGNAL X** | Encoder signal is too weak, e.g. when an encoder is contaminated. |
| **PROB. ERROR** | Before touching off on the workpiece, the tool must move by a distance of at least 0.2 mm. |
| **DSR MISSING** | The connected device is not transmitting a DSR signal. |
| **ERR. REF. X** | The spacing of the reference marks as defined in P43 is not the same as the actual spacing. |
| **FORMAT. ERR.** | Data format, baud rate etc. do not match. |
| **FRQ. ERR X** | The input frequency for this encoder input is too high. This can occur when the scale is moved too fast. |
| **ERR. MEMORY** | Check sum error: Check the datum, operating parameters and compensation values for multipoint axis error compensation. If the error recurs, contact your service agency! |

**To erase error messages:**
After you have removed the cause of error:
➤ Press the CL key.

# Part II Installation and Specifications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## Items Supplied

- **ND 720** for 2 axes
  or
- **ND 760** for 3 axes

- **Power connector** Id. Nr. 257 811-01

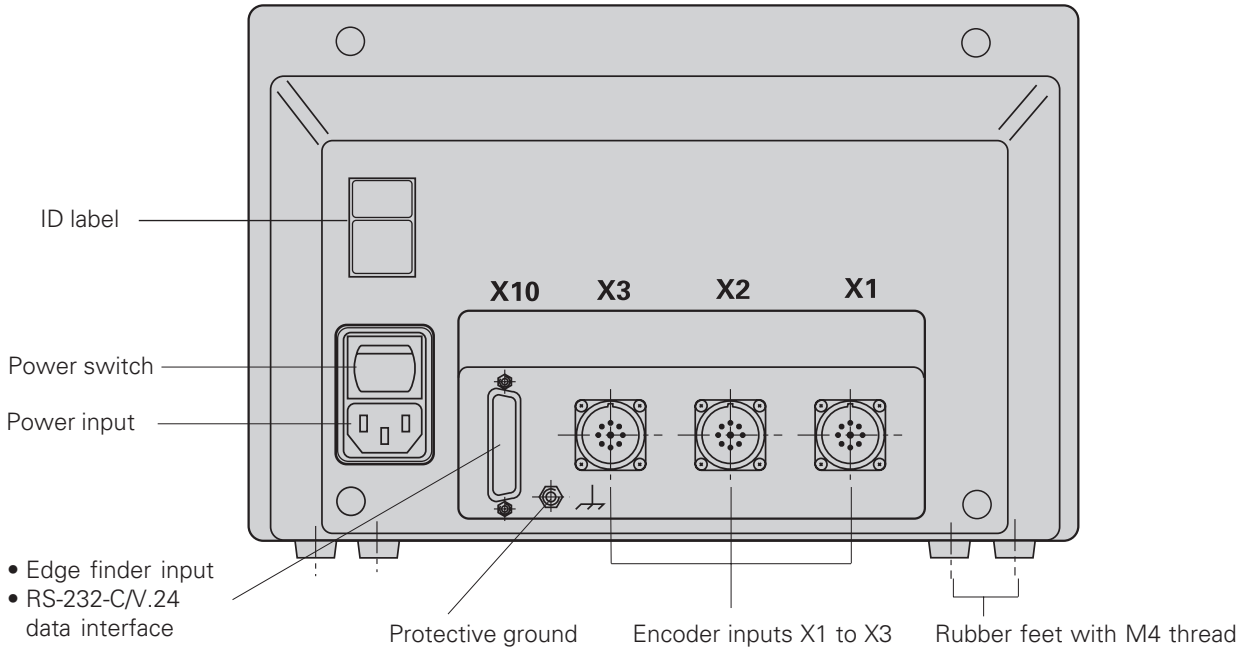
- **User's Manual**

### Optional Accessories

- **Tilting base** for housing bottom
  Id. Nr. 281 619-01

- **KT 130 Edge Finder** Id. Nr. 283 273-01

## Connections on Rear Panel

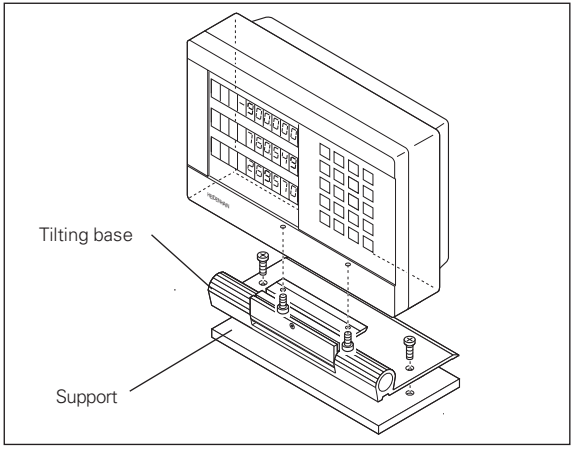



The interfaces X1, X2, X3, and X10 comply with the requirements for electrical separation according to EN 50178!

## Mounting

**ND 720/ND 760**

To mount the display unit on a support, use the M4 threaded holes in the rubber feet. You can also mount the display unit on the optional tilting base.



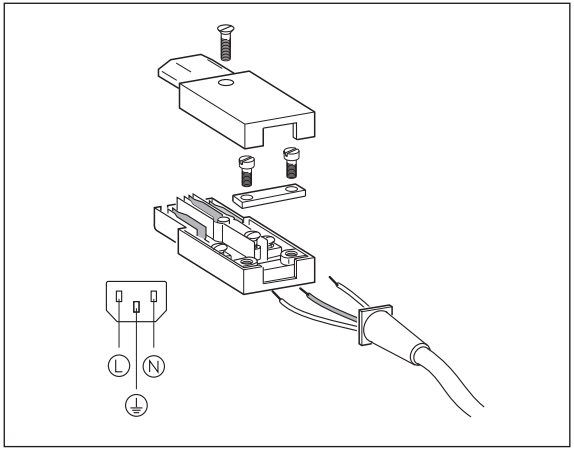

## Power Connection

Power leads: Ⓛ and Ⓝ,
Connect protective ground to ⏚ !

- **Danger of electrical shock!**
  Connect a protective ground. This connection must never be interrupted.
- Unplug the power cord before opening the housing.

To increase the noise immunity, connect the ground terminal on the rear panel to the central ground point of the machine. (Minimum cross-section: 6 mm²).

The display unit will operate over a voltage range of 90 Vac to 260 Vac. A voltage selector is therefore not necessary.



## Connecting the Encoders

Your display unit will accept all HEIDENHAIN linear encoders with sinusoidal output signals (7 to 16 $\mu A_{pp}$) and distance-coded or single reference marks.

### Assignment of the encoder inputs

Encoder input X1 is for the X axis
Encoder input X2 is for the Y axis
Encoder input X3 is for the Z axis (ND 760 only)

### Encoder monitoring system

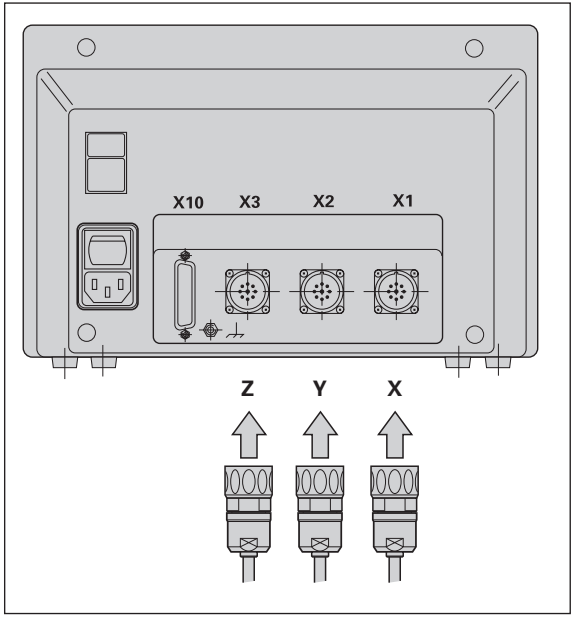
Your display unit features a monitoring system for checking the amplitude and frequency of the encoder signals. If it detects a faulty signal, one of the following error messages will be generated:

```
SIGNAL X
FRQ. X
```

Encoder monitoring can be activated with parameter P45.

If you are using linear encoders with distance-coded reference marks, the encoder monitoring system also checks whether the spacing of the reference marks as defined in parameter P43 is the same as the actual spacing on the scales. If it is not, the following error message will be generated:

```
ERR. REF. X
```



## Operating parameters

Operating parameters allow you to modify the operating characteristics of your display unit and define the evaluation of the encoder signals. Operating parameters that can be changed by the user are called user parameters, and can be accessed with the SPEC FCT key and the dialog "PARAMETER" (user parameters are identified as such in the parameter list). The full range of parameters can only be accessed through the dialog "CODE" and by entering 95148.

Operating parameters are designated by the letter P and a number. Example: **P11.** The parameter designation is shown in the input field when you select it with the DATUM and ENT key in the X display. The parameter setting is shown in the Y display.

Some operating parameters have separate values for each axis. In the **ND 760,** these parameters are identified by an index of 1 to 3, and in the **ND 720** by an index of one to two.

**Example:** P12.1 scaling factor, X axis
P12.2 scaling factor, Y axis
P12.3 scaling factor, Z axis (ND 760 only)

The operating parameters are preset before the unit leaves the factory. These factory default settings are indicated in the parameter list in **boldface type**.

## Entering and changing operating parameters

### To access the operating parameters

- ➤ Press the SPEC FCT key.
- ➤ Press the SPEC FCT key or |1 |2 , until "PARAMETER" appears in the X display.
- ➤ Confirm your selection by pressing ENT.
- ➤ If required, press the |1 |2 key to enter the code number **95148** and access the complete list of operating parameters.

### To page through the operating parameters

- ➤ Page forwards by pressing the ENT key.
- ➤ Page backwards by pressing the |1 |2 key.

### To change parameter settings

- ➤ Press the minus key or enter the value and confirm with the ENT key.

### To correct an entry

- ➤ Press CL: the old value reappears in the input line and becomes effective again.

### To exit the operating parameters

- ➤ Press the SPEC FCT or CL key.

**P1 Unit of measure** [1)]

| | |
|---|---|
| Display in millimeters | MM |
| Display in inches | INCH |

**P3.1 to P3.3 Radius/diameter display** [1)]

| | |
|---|---|
| Display position value as radius | **RADIUS** |
| Display position value as diameter | DIAMETER |

**P11 Activate scaling factor** [1)]

| | |
|---|---|
| Active | SCALING ON |
| Not active | **SCALING OFF** |

**P12.1 to P12.3 Define scaling factor** [1)]

Enter a scaling factor separately for each axis:
Entry value > 1: workpiece will "grow"
Entry value = 1: workpiece will remain the same size
Entry value < 1: workpiece will "shrink"

| | |
|---|---|
| Input range: | 0.100000 to 9.999999 |
| Default setting: | **1.000000** |

**P25 Stylus diameter** [1)]

| | |
|---|---|
| Input range (mm): | 0.000 to 999.999 |
| Default setting: | **6** |

**P26 Stylus length** [1)]

| | |
|---|---|
| Input range (mm): | **0.000** to 999.999 |

**P30.1 to P30.3 Counting direction**

| | |
|---|---|
| Positive counting direction with positive direction of traverse | **DIRECT. POS** |
| Negative counting direction with positive direction of traverse | DIRECT. NEG |

**P32.1 to P32.3 Subdivision of the encoder signals**

1024 / 1000 / 800 / 512 / 500 / 400 / 256 / 200 / 128 / 100 / 80 / 64 / 50 / 40 / **20** / 10 / 8 / 5 / 4 / 2 / 1 / 0.8 / 0.5 / 0.4 / 0.2 / 0.1

**P33.1 to P33.3 Counting mode**

0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9
0 - 2 - 4 - 6 - 8
0 - 5

**P38.1 to P38.3 Decimal places**

2 / **3** / 4 / 5 / 6 / 7 / 8

[1)] User parameter

### P40.1 to P40.3 Select type of axis error compensation

| | |
|---|---|
| No axis error compensation | **CORR. OFF** |
| Linear error compensation active, multipoint error comp. not active | CORR. LIN |
| Multipoint error compensation active, linear error compensation not active | CORR. ABS |

### P41.1 to P41.3 Linear axis error compensation

Input range (µm): –99999 to +99999
Factory default setting: **0**

**Example:** Displayed length $L_d$ = 620.000 mm
Actual length (as determined for example with the VM 101 from HEIDENHAIN)
$L_a$ = 619.876 mm
Difference $\Delta L = L_a - L_d = -124$ µm
Compensation factor k:
$k = \Delta L/L_d = -124$ µm/0.62 m = **– 200** [µm/m]

### P43.1 to P43.3 Reference marks

| | | |
|---|---|---|
| One reference mark | SINGLE | REF.M. |
| Distance-coded with 500 • SP | 500 | SP |
| Distance-coded with 1000 • SP | **1000** | **SP** |
| Distance-coded with 2000 • SP | 2000 | SP |
| Distance-coded with 5000 • SP | 5000 | SP |

(SP: signal period)

### P44.1 to P44.3 Reference mark evaluation

| | |
|---|---|
| Evaluation | **REF. X ON** |
| No evaluation | REF. X OFF |

### P45.1 to P45.3 Encoder monitoring

| | |
|---|---|
| Amplitude and frequency monitoring | **ALARM ON** |
| No monitoring | ALARM OFF |

### P48.1 to P48.3 Activate axis display

| | |
|---|---|
| Axis display active | **AXIS ON** |
| Not active | AXIS OFF |

### P49.1 to P49.3 Axis designation for measured value output[1)]

An axis designation for the measured value output can be set through the number of the ASCII character. The axis designation is output together with the measured value.

| | | |
|---|---|---|
| Input range: | 0 to 127 | |
| Measured value output disabled | 0 | |
| ASCII character from ASCII table | 1 to 127 | |
| Default setting: | P49.1 | **88** |
| | P49.2 | **89** |
| | P49.3 | **90** |

### P50 Baud rate [1)]

110 / 150 / 300 / 600 / 1200 / 2400 / 4800 / **9600** / 19 200 / 38 400

### P51 Line feeds for measured value output [1)]

Input range: 0 to 99
Default setting: **1**

[1)] User parameter

**P80 Function of the CL key**

| | |
|---|---|
| Set to zero with CL | `CL....RESET` |
| No set to zero with CL | `CL......OFF` |

**P96 Measured value output for probing**

| | |
|---|---|
| Measured value output active | `PROBE ON` |
| Measured value output not active | **`PROBE OFF`** |

**P97 Characters for measured values**

ASCII characters for designation of the measured values for output through probing, contact, or pulse.

| | |
|---|---|
| Input range: | **0** to 127 |
| No ASCII character | 0 |
| ASCII character from ASCII table | 1 to 127 |

**P98 Conversational language** [1)]

| | |
|---|---|
| German | **`LANGUAGE D`** |
| English | `LANGUAGE GB` |
| French | `LANGUAGE F` |
| Italian | `LANGUAGE I` |
| Dutch | `LANGUAGE NL` |
| Spanish | `LANGUAGE E` |
| Danish | `LANGUAGE DK` |
| Swedish | `LANGUAGE S` |
| Finnish | `LANGUAGE FI` |
| Czech | `LANGUAGE CZ` |
| Polish | `LANGUAGE PL` |
| Hungarian | `LANGUAGE H` |
| Portuguese | `LANGUAGE P` |

[1)] User parameter

## Linear Encoders

### Selecting the display step with linear encoders

To select a certain display step you must define the following operating parameters:

- Subdivision (P32)
- Counting mode (P33)
- Decimal points (P38)

**Example**
Linear encoder with a signal period of 10 µm

Desired display step ..... 0.000 5 mm
Subdivision (P32) ..... 20
Counting mode (P33) ..... 5
Decimal places (P38) ..... 4

The following tables will help you select the parameters.

**Display step, signal period and subdivision for linear encoders**

| Display step | | Signal period [µm] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 4 | 10 | 20 | 40 | 100 | 200 | 12 800 |
| [mm] | [inch] | P32: Subdivision | | | | | | | |
| 0.000 005 | 0.000 000 2 | 400 | – | – | – | – | – | – | – |
| 0.000 01 | 0.000 000 5 | 200 | – | – | – | – | – | – | – |
| 0.000 02 | 0.000 001 | 100 | – | – | – | – | – | – | – |
| 0.000 05 | 0.000 002 | 40 | 80 | – | – | – | – | – | – |
| 0.000 1 | 0.000 005 | 20 | 40 | 100 | 200 | – | – | – | – |
| 0.000 2 | 0.000 01 | 10 | 20 | 50 | 100 | – | – | – | – |
| 0.000 5 | 0.000 02 | 4 | 8 | **20** | 40 | 80 | – | – | – |
| 0.001 | 0.000 05 | 2 | 4 | 10 | 20 | 40 | 100 | – | – |
| 0.002 | 0.000 1 | 1 | 2 | 5 | 10 | 20 | 50 | 100 | – |
| 0.005 | 0.000 2 | 0.4 | 0.8 | 2 | 4 | 8 | 20 | 40 | – |
| 0.01 | 0.000 5 | 0.2 | 0.4 | 1 | 2 | 4 | 10 | 20 | – |
| 0.02 | 0.001 | – | – | 0.5 | 1 | 2 | 5 | 10 | – |
| 0.05 | 0.002 | – | – | 0.2 | 0.4 | 0.8 | 2 | 4 | 256 |
| 0.1 | 0.005 | – | – | 0.1 | 0.2 | 0.4 | 1 | 2 | 128 |
| 0.2 | 0.01 | – | – | – | – | – | – | – | 64 |

**Parameter settings for HEIDENHAIN linear encoders with 11 $\mu A_{PP}$ signals**

| Model | Signal period [µm] | Reference marks | Millimeters | | | | Inches | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Display step [mm] | Subdivision | Count | Decimal places | Display step [inch] | Subdivision | Count | Decimal places |
| | | P 43 | | P 32 | P 33 | P 38 | | P 32 | P 33 | P 38 |
| CT<br>MT xx01 | 2 | single | 0,0005<br>0,0002 | 4<br>10 | 5<br>2 | 4<br>4 | 0,00002<br>0,00001 | 4<br>10 | 2<br>1 | 5<br>5 |
| LIP 401A/401R | | -/single | 0,0001<br>0,00005 | 20<br>40 | 1<br>5 | 4<br>5 | 0,000005<br>0,000002 | 20<br>40 | 5<br>2 | 6<br>6 |
| | | | *Recommended only for LIP 401* | | | | | | | |
| | | | 0,00002<br>0,00001<br>0,000005 | 100<br>200<br>400 | 2<br>1<br>5 | 5<br>5<br>6 | 0,000001<br>0,0000005<br>0,0000002 | 100<br>200<br>400 | 1<br>5<br>2 | 6<br>7<br>7 |
| LF 103/103C<br>LF 401/401C<br>LIF 101/101C<br>LIP 501/501C | 4 | single/5000 | 0,001<br>0,0005<br>0,0002<br>0,0001 | 4<br>8<br>20<br>40 | 1<br>5<br>2<br>1 | 3<br>4<br>4<br>4 | 0,00005<br>0,00002<br>0,00001<br>0,000005 | 4<br>8<br>20<br>40 | 5<br>2<br>1<br>5 | 5<br>5<br>5<br>6 |
| LIP 101 | | single | 0,00005 | 80 | 5 | 5 | 0,000002 | 80 | 2 | 6 |
| | | | *Recommended only for LIP 101* | | | | | | | |
| | | | 0,00002<br>0,00001 | 200<br>400 | 2<br>1 | 5<br>5 | 0,000001<br>0,0000005 | 200<br>400 | 1<br>5 | 6<br>7 |
| MT xx | 10 | single | 0,0005<br>0,0002<br>0,0001 | 20<br>50<br>100 | 5<br>2<br>1 | 4<br>4<br>4 | 0,00002<br>0,00001<br>0,000005 | 20<br>50<br>100 | 2<br>1<br>5 | 5<br>5<br>6 |
| **LS 303/303C**<br>**LS 603/603C** | 20 | single/1000 | 0,01<br>0,005 | 2<br>4 | 1<br>5 | 2<br>3 | 0,0005<br>0,0002 | 2<br>4 | 5<br>2 | 4<br>4 |

**Parameter settings for HEIDENHAIN linear encoders with 11 $\mu A_{PP}$ signals (continued)**

| Model | Signal period [µm] | Reference marks | Millimeters | | | | Inches | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Display step [mm] | Subdivision | Count | Decimal places | Display step [inch] | Subdivision | Count | Decimal places |
| | | P 43 | | P 32 | P 33 | P 38 | | P 32 | P 33 | P 38 |
| **LS 106/106C**<br>**LS 406/406C**<br>**LS 706/706C** | 20 | single/1000 | 0,001<br>0,0005 | 20<br>40 | 1<br>5 | 3<br>4 | 0,00005<br>0,00002 | 20<br>40 | 5<br>2 | 5<br>5 |
| ST 1201 | | - | | | | | | | | |
| **LB 302/302C**<br>LIDA 10x/10xC | 40 | single/2000 | 0,005<br>0,002<br>0,001<br>0,0005 | 8<br>20<br>40<br>80 | 5<br>2<br>1<br>5 | 3<br>3<br>3<br>4 | 0,0002<br>0,0001<br>0,00005<br>0,00002 | 8<br>20<br>40<br>80 | 2<br>1<br>5<br>2 | 4<br>4<br>5<br>5 |
| | | | *Recommended only for LB 302* | | | | | | | |
| | | | 0,0002<br>0,0001 | 200<br>400 | 2<br>1 | 4<br>4 | 0,000001<br>0,0000005 | 200<br>400 | 1<br>5 | 5<br>6 |
| LB 301/301C | 100 | single/1000 | 0,005<br>0,002<br>0,001 | 20<br>50<br>100 | 5<br>2<br>1 | 3<br>3<br>3 | 0,0002<br>0,0001<br>0,00005 | 20<br>50<br>100 | 2<br>1<br>5 | 4<br>4<br>5 |
| LIM 102 | 12800 | single | 0,1<br>0,05 | 128<br>256 | 1<br>5 | 1<br>2 | 0,005<br>0,002 | 128<br>256 | 5<br>2 | 3<br>3 |

**Example:**
Your encoder: LS 303 C, desired display step: 0,005 mm (5 µm), parameter settings: P01 = mm, P43 = 1 000, P32 = 4, P33 = 5, P38 = 3

## Multipoint Axis Error Compensation

If you want to use the multipoint axis error compensation feature, you must
- activate this feature with operating parameter 40 (see "Operating Parameters"),
- traverse the reference marks after switching on the display unit,
- enter a compensation value table.

Your machine may have a nonlinear axis error due to factors such as axis sag or drivescrew errors. Such deviations are usually measured with a comparator measuring system (such as the HEIDENHAIN VM 101).

You can, for example, determine the screw pitch error X=F(X) for the X axis.

An axis can only be corrected in relation to **one** axis that has an error. In each axis, a compensation value table with 16 compensation values can be generated. You can select the compensation table with the SPEC FCT key and the "PARAMETER\CODE" dialog.

To determine the compensation values (e.g. with a VM 101), the REF display must be selected after selecting the compensation-value table.

| | |
|---|---|
| R+/- | Select the REF. |

**Entries in the compensation value table**

- Axis to be corrected: X, Y or Z (Z axis only with ND 760)
- Axis causing the error: X, Y or Z (Z axis only with ND 760)
- Datum for the axis to be corrected:
  Here you enter the point starting at which the axis with error is to be corrected. This point indicates the absolute distance to the reference point.

Do not change the datum point after measuring the axis error and before entering the axis error into the compensation table.

- Spacing of the compensation points
  The spacing of the compensation points is expressed as $2^X$ [µm].
  Enter the value of the exponent *x* into the compensation value table.
  Minimum input value: 6 (= 0.064 mm)
  Maximum input value: 20 (= 1048.576 mm)
  23 (= 8388.608 mm)

  **Example:** 900 mm traverse and 15 compensation points: results in 60.000 mm spacing between points.
  Nearest power of two: $2^{16}$ [µm] = 65.536 mm
  Entry in compensation value table: 16
- Compensation value
  You enter the measured compensation value (in millimeters) for the displayed compensation point. Compensation point 0 always has the value 0 and cannot be changed.

**Selecting the compensation table, entering an axis correction**

| | |
|---|---|
| SPEC FCT | Select special functions. |
| SPEC FCT or 1\|2 | Select the "Parameter" function if required, by repeatedly pressing the 1\|2 key |
| **PARAMETER** | |
| ENT 1\|2 | Select dialog for entering the code number. |
| **CODE** | |
| 1 0 5 2 9 6 ENT | Enter code number 105296 and confirm with ENT. |
| **AXIS X** | |
| X ENT | |
| **X FCT. X** | |
| X ENT | Enter the axis causing the error (e.g. X) (screw pitch error), and confirm with ENT. |
| **DATUM X** | |
| 2 7 ENT | Enter the active datum for the error on the axis to be corrected (e.g. 27 mm) and confirm with ENT. |
| **SPACING X** | |
| 1 0 ENT | Enter the spacing of the compensation points on the axis to be corrected, for example $2^{10}$ µm (equals 1024 mm) and confirm with ENT. |
| **27.000** | |
| ENT 0 • 0 1 ENT | Compensation point no. 1 is displayed. Enter the associated compensation value (e.g. 0.01 mm) and confirm with ENT. |
| **28.024** | |
| ENT 1\|2 | Enter all further compensation points. If you press the minus key, the unit will show the number of the current compensation point in the X display. |
| SPEC FCT or CL | Conclude entry. |

**Deleting a compensation value table**

| | |
|---|---|
| SPEC FCT | Select special functions. |
| SPEC FCT or ↓1/↓2 | Select "parameter." |
| **PARAMETER** | |
| ENT ↓1/↓2 | Select the dialog for entering the code number. |
| **CODE** | |
| 1 0 5 2<br>9 6 ENT | Enter the code number 105296 and confirm with ENT. |
| **AXIS X** | |
| Z CL | Select the compensation value table (e.g., for the Z axis), and delete the table. |
| **DELETE Z** | |
| ENT | Confirm with ENT, or cancel with CL. |
| SPEC FCT | Conclude entry. |

**Pin Layout of X10 for KT 130 Edge Finder and Data Interface**

| Pin | Signal | Function |
|---|---|---|
| 1 | | Internal shield |
| 2 | | Standby |
| 3 | RXD | **Receive data** |
| 4 | RTS | **Request to send** |
| 5 | CTS | **Clear to send** |
| 6 | | $U_P$ +5 V |
| 7 | SIGN. GND | **Signal ground** |
| 8 | | $U_P$ 0 V |
| 9 | TXD | **Transmit data** |
| 10 | DSR | **Data set ready** |
| 11 | DTR | **Data terminal ready** |
| 12 | | Meas. value output by contact |
| 13 | | Switching signals |
| 14 | | Meas. value output by pulse |
| 15 | CHASSIS GND | Housing |

## RS-232-C/V.24 (Option)

In addition to a connection for the edge finder, the X10 socket also provides an RS-232-C/V.24 data interface.

The data interface on your ND display unit enables you to use a printer or a PC for transferring measured values or programs.

The interface is permanently set to the following data format:

1 start bit
7 data bits
Even parity bit
2 stop bits

The baud rate is set with parameter P50.

For connection to peripheral devices you can use either full wiring (figure at upper right) or simplified wiring (below right).

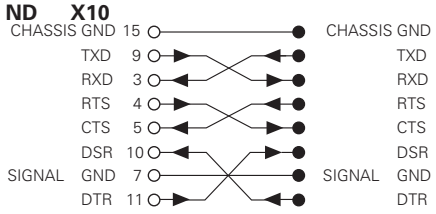
**Levels for TXD and RXD**

| Logic levels | Voltage levels |
|---|---|
| "1" | – 3 V to – 15 V |
| "0" | + 3 V to +15 V |

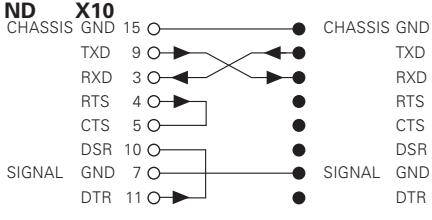
**Levels for RTS, CTS, DSR and DTR**

| Logic levels | Voltage levels |
|---|---|
| "1" | + 3 V to +15 V |
| "0" | – 3 V to – 15 V |

Full wiring




Simplified wiring



## Measured Value Output

Measured values can be output over the RS-232-C/V.24 interface. This can be done with the following functions:

Probing with the KT edge finder
Contact input on X10
Pulse input on X10
CTRL B over the RS-232-C interface

### Code letters with the measured value

Parameter P97 allows you to select a code letter to be output together with the measured value when using Probe, Contact or Pulse. The decimal number you enter in the parameter is the ASCII character number in the ASCII table. If you enter 0, no code letter will be output. The code letter enables you to recognize whether the measured value was generated with CTRL B or with an external signal.

### Axis designation for measured value output

Parameter P49 allows you to enter an axis designation for each measured value that is output. The decimal number you enter in the parameter is the ASCII character number in the ASCII table. If you enter 0, no axis designation will be output.

### Example of measured value output:

Parameter settings:

| | | | |
|---|---|---|---|
| P49.1 | = | 88 | (“X”) |
| P49.2 | = | 89 | (“Y”) |
| P49.3 | = | 90 | (“Z”) |
| P51 | = | 0 | (no blank lines) |
| P97 | = | 69 | (“E”) |

Output:

E (CR)(LF)
X=...(CR)(LF)
Y=...(CR)(LF)
Z=...(CR)(LF)

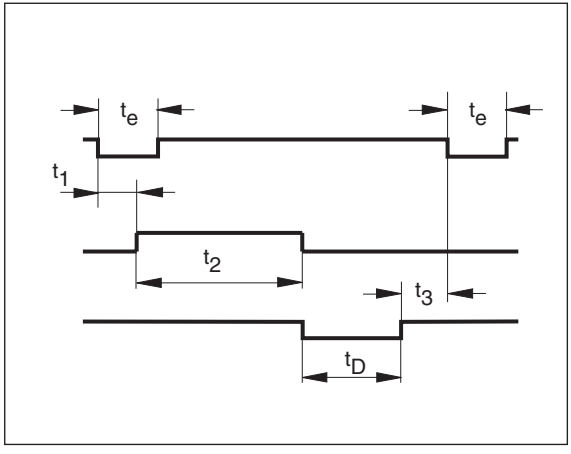
**Measured value output when probing**

Parameter P96 allows you to activate measured value output when probing with the KT edge finder. The edge finder is connected to D-sub input X10.

Whenever the Probe Edge function is used, your display unit outputs the position of the edge in the selected axis and the actual positions of the other axes over the TXD line of the RS-232-C/V.24 interface.

Whenever the Probe Midpoint function is used, your display unit outputs the calculated midpoint in the selected axis and the actual positions of the other axes.

Measured value output with CTRL B is disabled when a probing function is active.




**Delay times with data output**

| | |
|---|---|
| Duration of the latch signal: | $t_e \geq 4$ µs |
| Storage delay: | $t_1 \leq 4.5$ ms |
| Data output after: | $t_2 \leq 50$ ms |
| Regeneration time: | $t_3 \geq 0$ |

Duration of data output in seconds:

$$t_D = \frac{209 \bullet \text{number of axes} + 11 \bullet \text{number of blank lines}}{\text{Baud rate}} * 1.08$$

Next possible signal for measured value output: $t_E = t_1 + t_2 + t_D + t_3$ [s]

**Examples of measured value output when probing**

Example: Probe Edge, X axis

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P | R | X | : | + | 58541 | . | 2504 | | R | <CR> | <LF> |
| Y | | | : | – | 10122 | . | 8660 | | R | <CR> | <LF> |
| Z | | | : | + | 85903 | . | 3042 | ? | R | <CR> | <LF> |

Example: Probe Midpoint, X axis

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C | L | X | : | + | 34761 | . | 2504 | | R | <CR> | <LF> |
| Y | | | : | – | 10122 | . | 8660 | | R | <CR> | <LF> |
| Z | | | : | + | 85903 | . | 3042 | | R | <CR> | <LF> |
| ① | | | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ | ⑨ | ⑩ |

① Probed axis <PR>, <CL> / other axes
② Colon
③ Plus or minus sign
④ 1 to 8 places before the decimal point
⑤ Decimal point
⑥ 1 to 8 decimal places
⑦ Unit: blank = mm, " = inches, ? = error message
⑧ R = radius display, D = diameter display
⑨ Carriage Return
⑩ Line Feed

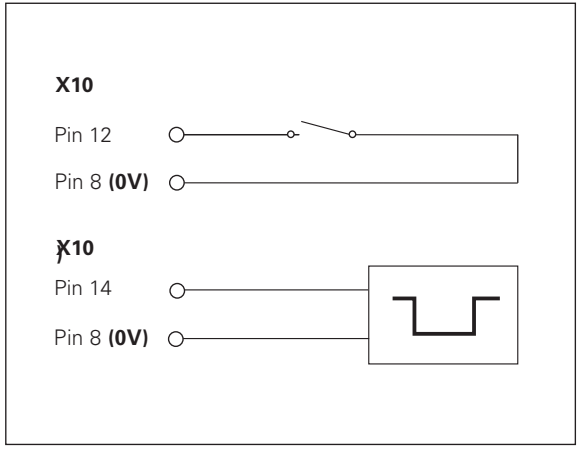
**Measured value output over the contact and pulse inputs**

Measured value output over the contact input (pin 12 on X10) and pulse input (pin 14 on X10) can be triggered when these inputs are closed against 0 V.

The measured values are output over the TXD line of the RS-232-C interface.

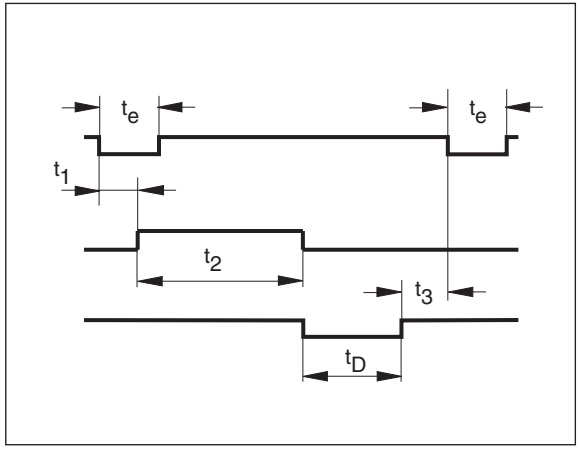
A commercially available switch can be attached to the contact input. This switch generates a signal for data output when it makes contact against 0 V.

The pulse input can be triggered with TTL logic devices (for example, SN74LSXX).




**Delay times for data output**

| | |
|---|---|
| Latch signal duration: Pulse | $t_e \geq 1.2\ \mu s$ |
| Latch signal duration: Contact | $t_e \geq 7\ ms$ |
| Storage delay: Pulse | $t_1 \leq 0.8\ \mu s$ |
| Storage delay: Contact | $t_1 \leq 4.5\ ms$ |
| Data output after | $t_2 \leq 30\ ms$ |
| Regeneration time | $t_3 \geq 0$ |




Duration of data output in seconds:

$$t_D = \frac{187 \bullet \text{number of axes} + 11 \bullet \text{number of blank lines}}{\text{Baud rate}} * 1.08$$

Next possible signal for measured value output: $t_E = t_1 + t_2 + t_D + t_3$ [s]

### Measured value output with CTRL B

If the control character STX (CTRL B) is received over the RS-232-C interface, the measured value referenced to this time point will be sent over the interface. CTRL B is received over the RXD line and the measured values are output over the TXD line.

**BASIC program for measured value output:**

```
10    L%=48
20    CLS
30    PRINT "RS232/V.24"
40    OPEN "COM1:9600,E,7" AS#1
50    PRINT #1, CHR$ (2);
60    IF INKEY$<>""THEN 130
70    C%=LOC(1)
80    IF C%<L%THEN 60
90    X$=INPUT$(L%,#1)
100   LOCATE 9,1
110   PRINT X$;
120   GOTO 50
130   END
```

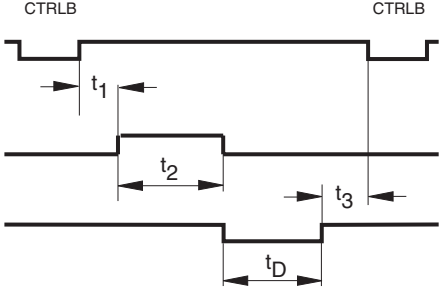
### Delay times for data output

| | |
|---|---|
| Storage delay | $t_1 \leq$ 0.5 ms |
| Data output follows $t_2$ | $t_2 \leq$ 30 ms |
| Regeneration time after data output | $t_3 \geq$ 0 ms |

Duration of data output in seconds:

$$t_D = \frac{187 \bullet \text{number of axes} + 11 \bullet \text{number of blank lines}}{\text{Baud rate}} * 1.08$$

Next possible signal for measured value output: $t_E = t_1 + t_2 + t_D + t_3$ [s]



**Example of measured value output over the contact and pulse inputs or CTRL B:**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| E | <CR> | <LF> | | | | | | | |
| X | = | + | 58541 | . | 2504 | | R | <CR> | <LF> |
| Y | = | - | 10122 | . | 8660 | | R | <CR> | <LF> |
| Z | = | + | 85903 | . | 3042 | | R | <CR> | <LF> |
| ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ | ⑨ | ⑩ |

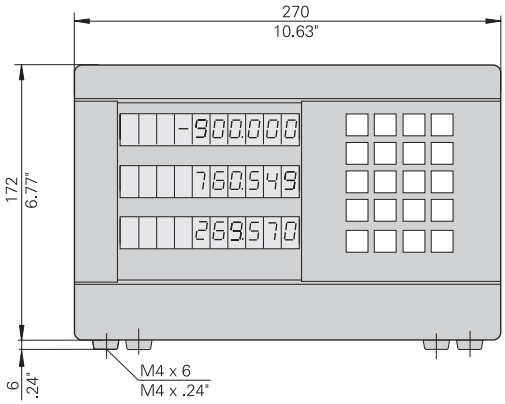
① Axis designation
② Equality sign
③ Plus or minus sign
④ 1 to 8 places before the decimal
⑤ Decimal point
⑥ 1 to 8 places after the decimal
⑦ Unit: blank = mm, " = inches, ? = error message
⑧ R(r) = radius display, D(d) = diameter display, ( ) = distance-to-go display
⑨ Carriage Return
⑩ Line Feed

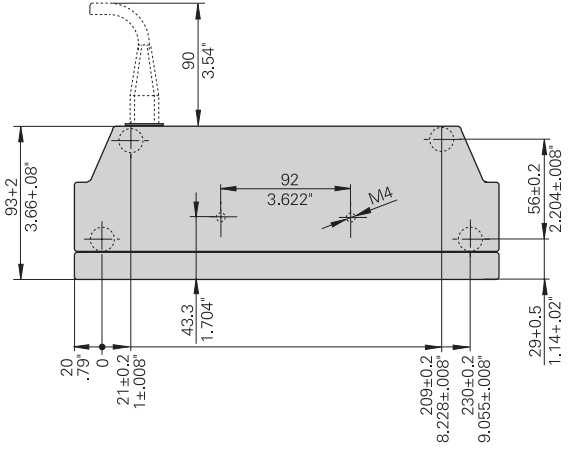
## Specifications

| | |
|---|---|
| **Housing** | ND 720/ND 760<br>Bench-top design, cast-metal housing<br>Dimensions (W • H • D)<br>270 mm • 172 mm • 93 mm |
| **Oper. temperature** | 0° to 45° C (32° to 113° F) |
| **Storage temperature** | –20° to 70° C (–4° to 158° F) |
| **Weight** | Approx. 2.3 kg (5 lb) |
| **Relative humidity** | <75% annual average<br><90% in rare cases |
| **Power supply** | 90 Vac to 260 Vac (–15% to +10%)<br>48 Hz to 62 Hz |
| **Power consumption** | 15 W |
| **Protection** | IP 40 as per IEC 529 |

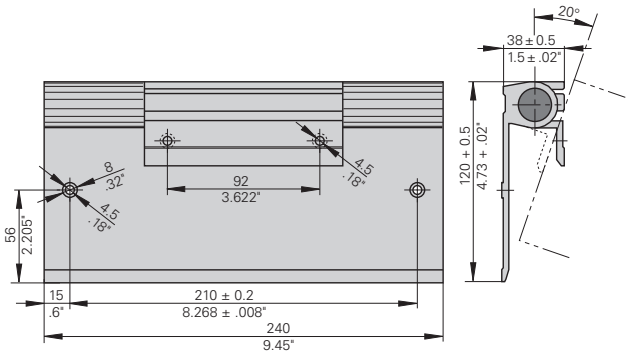
| | |
|---|---|
| **Encoder inputs** | For encoders with 7 to 16 $\mu A_{PP}$<br>Grating period 2, 4, 10, 20, 40, 100, 200 µm and 12.8 mm<br>Refe rence mark evaluation for distance-coded and single reference marks |
| **Input frequency** | Max. 100 kHz for 30 m (98.5 ft) cable length |
| **Display step** | Adjustable<br>(see "Linear Encoders") |
| **Datums** | 2 (nonvolatile) |
| **Functions** | – Tool radius compensation<br>– Distance-to-go display<br>– Probing functions<br>– Circular & linear hole patterns<br>– Scaling factor<br>– Measured value output |
| **RS-232/V.24 Interface** | Baud rates adjustable<br>110, 150, 300, 600, 1200, 2400, 4800, 9600, 19 200, 38 400 |

## Dimensions in mm/inches




## Tilting base



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